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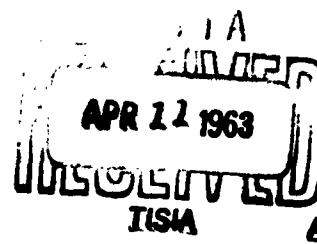
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THIRTY-THIRD PROGRESS REPORT

REPORT #17

ON THE DESIGN AND DEVELOPMENT

OF AN INERTIAL ALTITUDE SYSTEM

COVERING SEPTEMBER 1962

ARACON Laboratories
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Concord, Massachusetts

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THIRTY-THIRD PROGRESS REPORT
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REPORT #17 ON THE DESIGN AND DEVELOPMENT
OF AN INERTIAL ALTITUDE SYSTEM
COVERING PERIOD FROM 1 SEPTEMBER 1962 TO 30 SEPTEMBER 1962

Prepared for
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1. INTRODUCTION

ARACON Laboratories has the responsibility to develop an inertial altitude determination system and to deliver six system packages, a simple field test kit, installation instructions, and operating procedures to the project officer at Picatinny Arsenal. A summary of progress on the major elements of the electronics system and the gyro system is given in the following paragraphs.

2. ELECTRONIC SYSTEM DEVELOPMENT

Overall progress on the electronic system has been satisfactory with no unforeseen difficulties or delays encountered. The following paragraphs outline the status of the major elements of the electronic system.

Double Integration System - The second unit has been completed and tested. Difficulty was encountered with temperature compensation due to thermistor deviation. This was corrected by changing the value of the parallel resistor.

Timing Control Unit - The basic design and the schematic diagram for this unit have been completed.

Comparators - The comparators were tested with satisfactory results during this report period.

Operational Power Supply - Trouble was encountered with the first Hyperion operational power supply during test. This unit has been returned to Hyperion for repairs.

Test Power Supply - The basic design of this power supply, used for laboratory tests, was completed during this report period.

Interconnection Cable - The interconnection wiring diagram has been completed and cable fabrication is underway.

Acceptance Test Specification - A preliminary draft of the acceptance test specification has been completed and is undergoing review.

3. GYRO SYSTEM DEVELOPMENT

As mentioned in last month's report, in order to expedite the development completion of unit 1, it was decided that Mr. Gibson of Picatinny and Mr. Smith of ARACON would remain at GTI as long as necessary to assist in the troubleshooting, debugging and redesign of the platform system. The following is a detailed account of the work that was accomplished at GTI. The major effort was spent at the subsystem level, and considerable work was needed to bring the gyro to the point where meaningful tests could be made on system operation.

Roll Gimbal Servo Amplifiers

The first problem to be worked on involved the biasing arrangement for the silicon controlled rectifiers (SCR's) in the Roll Gimbal servo amplifiers. The SCR's were supposed to be biased "on" when no signal is being applied, but their operation was very uncertain as they would go off occasionally causing the roll gimbal to jump erratically.

Two approaches were used to correct this problem. First, the SCR biasing arrangement was changed to provide a higher value of bias at a lower impedance level, thus making the circuit less sensitive to induced external noise which seemed to be causing most of the trouble. Secondly, the input signal leads to the RG amplifier were shielded and the ground connections cleaned up. (Some heavy current loads shared a common ground path with the RG.) After this work was accomplished the RG servos operated satisfactorily.

Rate Amplifier

The rate amplifier used in conjunction with a tachometer to provide damping for the RG had not been installed. This was done and some additional minor changes were made to it to improve operation. The rate amplifier provided sufficient damping so that the RG was stable and did not oscillate when the system was in Cage Mode.

SCR Burnout

It was noticed that SCR's were beginning to fail at an alarming rate. Although accidental short circuits during testing explained many failures, the residual failure level was still high enough to cause worry. Furthermore, the original SCR's used in the original circuit were no longer available because SSPI was having too much trouble with their production line on that unit (critical specs: 275 volt inverse, 5 amp peak current).

On investigating the problem, it was discovered that the method for producing quadrature in the RG servo motors and the torquers was putting approximately 400 volts inverse across the SCR's causing them to punch through and ultimately melt. This circuit was changed to prevent such large inverse voltages from appearing at the SCR's and found that a smaller current unit, readily available from SSPI would now satisfy the circuit requirements. Several were tried in both the RG and torque amplifiers with excellent results.

Oscillation in Donner Accelerometer

After the above work was completed, it was decided to make some preliminary tests on the erection system and it was planned to use the accelerometer output for check purposes. However, when the accelerometer was connected to a sensitive DC voltmeter, fairly large low frequency excursions of the null were noted. Although these variations could be considered to be within specs, the operation seemed anomalous, so the accelerometer output was connected to an oscilloscope (never before done at GTI) and disclosed that the accelerometer was oscillating at approximately 600 cps, at a nearly full scale amplitude.

The accelerometer leads were then shielded, completely eliminating the oscillation and the accelerometer was found to work extremely well. Apparently some of the 2 mc carrier used for the sensor pickoff in the accelerometer is leaking into the system wires because of the unshielded length of wire at the slip rings. This 2 mc signal is carried back into the accelerometer on the ± 20 volt lines and upsets the operational amplifier. It is apparently necessary to shield all accelerometer power lines, even short runs of 3 or 4 inches. When this is done, no problem exists.

Caging

Several problems were encountered in the caging operation. A major source of trouble resulted from attempts to crowd too many functions onto a single control line. This resulted in noisy grounds which introduced spurious signals into the caging amplifiers and also provided the opportunity for sneak paths to occur during other modes of operation.

Approximately a week was spent in the fairly tedious work of tracking down and eliminating such effects. In addition to this, several minor changes were required in the control panel to provide proper timing between the various phases of the caging operation.

After eliminating these problems, the caging operation proceeded smoothly and very satisfactorily.

Erection

The most delicate and therefore the most difficult operation in the system is erection. Since the gravity sensors are carried on the redundant gimbal, proper erection of the gyro depends on matching the scale factors of the MG microsyn and the EP 10 liquid potentiometer (proportional gravity sensor). The first step therefore was to calibrate the microsyn and EP 10 individually. Both calibrations were fairly difficult, the present EP 10 develops bubbles and changes scale factor if tipped too far or shaken too much. Several EP 10's were tried before a partially satisfactory unit was found. New units will be obtained which do not have this shortcoming.

The microsyn could not be calibrated directly because of the difficulty of measuring the middle gimbal angles accurately enough. Therefore, an identical unit was calibrated in a bench test setup. (Microsyzs in subsequent units will be calibrated before installation.)

When the calibrations had been completed the correct bridge resistors were calibrated and installed, at this time it was discovered that the torquer operation tended to become very erratic as the gyro heated up. Investigation revealed that the bias on the SCR's in the torquer amplifiers was decreasing at high temperatures, and noise pulses were

being picked up causing the SCR's to fire. This problem was eliminated by providing a lower impedance bias supply and by bridging the gate and cathode of the SCR with a small condenser to bypass the noise pulses. This produced proper operation of the torquer amplifiers, however the erection still was not satisfactory, in that a large dead zone was found. This turned out to be due to a very high friction level in the middle gimbal resulting from an improperly installed retractable wiper block. This was corrected and the dead zone decreased to an acceptable level.

At this point, so many changes had been made to the gyro electronics that it was decided to repeat the entire calibration procedure for caging and erection. This was done and satisfactory results were obtained.

Launch Mode

It was now possible to begin to run static drift tests on the gyro. First, however, it was necessary to build and install a dither circuit to produce small perturbations in the RG position. This was done and preliminary drift tests were run.

The results were very erratic, and there were indications of damage to the motor and gimbal bearings. Considerable vibration and noise existed when the motor was run at full speed. As the electronic work was essentially complete, the decision was made to disassemble the gyro and inspect the bearings. When this was done, extensive brinelling was found. Brinell marks were also found in several new bearings which had not been removed from their sealed packages.

Summary

During this period the gyro electronics were checked extensively and given a very thorough workout. It is felt that satisfactory performance has been achieved; although some minor modifications may still be necessary. It is not expected that any further major problems will arise from the electronics.

4. MANPOWER SUMMARY

The schedule of manhours expended by ARACON from
1 September to 21 September 1962 was as follows:

Engineering	283
Engineering Support	<u>509 1/2</u>
Total	792 1/2